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GB 1588485	GB 1586327	GB 1431019
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(58) Field of search

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**(54) Flame retardant polyolefin compositions**

(57) Polyolefin compositions having superior mechanical properties, processability and flame retardancy can be obtained by blending polyolefin resin, a halogen-containing flame retardant, antimony trioxide, a crosslinking agent, a radical-generating agent and optionally a boron compound.

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## SPECIFICATION

## Flame retardant polyolefin composition

5 This invention relates to polyolefin compositions having high flame-retardancy. More particularly, it relates to polyolefin compositions having good mechanical properties, processability and flame retardancy.

10 On account of superiority in processability, chemical resistance, weatherability, electrical characteristics, etc, polyolefin resin is widely used in various products including electrical household appliances. On the other hand it has drawbacks in that it is extremely  
15 inflammable, liquefied by pyrolysis at the time of combustion, forms liquid drops with flaming or without flaming combustion, and burnt pieces cut by fusion tend to fall away (hereinafter the dropped or fallen materials will be referred to as "drip", and the  
20 tendency to form drips as the "dripping property").

The existence or not of drip is one of the important factors for evaluating flame-retardancy. Even when a resin is superior in self-extinguishing property, its flame-retardancy is ranked in a lower grade if it has  
25 drip. Thus an improvement of dripping property is one of the important problems with regard to flame-retarding techniques for such resins. Further, since polyolefin resin has a relatively higher crystallinity and non-polar properties, it is poor in compatibility  
30 with a flame-retardant, and shows a great reduction in physical properties upon addition of a flame-retardant. On this account, for flame retarding or retardance of polyolefin resin, various proposals have been made.

35 As general methods for making a flame retardant polyolefin composition, a simultaneous use of an organic-halogen-containing flame-retardant with a certain kind of metal oxide (Japanese patent publication 25061 of 1976) and addition of a nitrogen-  
40 containing compound, a boron-containing compound or a water-containing inorganic compound, as a flame-retardant, have prevailed. However, an organic halogen-containing flame-retardant is superior in self-extinguishing property but has the drawback in  
45 that drip is formed at the time of burning. On the other hand, an inorganic flame-retardant, e.g. magnesium hydroxide, is superior in dripping property, and has a certain extent of self-extinguishing property but has a drawback in that a high level of flame-retardancy  
50 requires a large addition of retardant. A polyolefin composition containing a large amount of incorporated inorganic compound suffers in deterioration of processing characteristics, due to the reduction in fluidity of the molten material and the reduction in  
55 mechanical properties of formed articles made from such a composition. The range of addition is limitative in practical use, because this reduction of mechanical strength of formed articles makes the attainment of a high level of flame-retardancy difficult.

60 In order to overcome these drawbacks, it has been proposed to use simultaneously a bromine-containing flame retardant and a borofluoride salt in polypropylene resin (Japanese laid open application No.

65 163937 of 1979); to mix ethylene-propylene rubber modified with a silane compound and a flame-retardant with polyethylene resin, followed by crosslinking with an organic peroxide (Japanese laid open patent application No. 110139 of 1980); to use  
70 simultaneously a silane coupling agent, ethylene-propylene rubber, chlorinated polyethylene and a flame-retardant in forming, followed by crosslinking with water (Japanese laid open patent application No. 45716 of 1980). However, according to the above-  
75 mentioned Japanese laid open application No. 163937 of 1979, the improvement of dripping property is still not in the state which can be said to be sufficient. The processes of Japanese laid open patent application No. 110139 of 1980 and No. 45716 of 1980 are those  
80 which have been applied to polyethylene, which create crosslinking very easily in the presence of an organic peroxide.

The present inventors concentrated their effort in trying to solve the above-mentioned problem relating  
85 to flame-retardant polyolefin compositions. As a result, they succeeded in obtaining flame-retardant polyolefin compositions which typically have improved mechanical strength in formed articles, greatly improved dripping property at the time of burning,  
90 and further improved drawdown of burnt resin pieces through melting and falling of drops of burnt resin pieces. Such compositions are obtained for example by (a) incorporating a crosslinking agent and a radical generating agent in a polyolefin resin either in the  
95 presence of a halogen-containing flame-retardant and antimony trioxide or in the presence of a halogen-containing flame-retardant, antimony trioxide and a boron compound, and subjecting the resulting mixture to melting and kneading treatment or (b) mixing  
100 either a halogen-containing flame-retardant and antimony trioxide or a halogen-containing flame-retardant, antimony trioxide and a boron compound, with a polyolefin resin having been, in advance, treated with a crosslinking agent and a radical  
105 generating agent and subjecting the resulting mixture to melting and kneading treatment.

As evident from the foregoing description, it is an object of the present invention to provide flame-retardant polyolefin compositions which can provide  
110 formed articles typically having improved mechanical strength, and greatly improved dripping property at the time of burning.

The compositions of the present invention have the following constitution:

115 (1) A flame retardant polyolefin composition obtained by blending various components, where the percentages are based upon the weight of the following (A) to (E) components, except where a different basis for the percentages is stated: (A) 0.1 to  
120 15% by weight of a crosslinking agent, (B) 0.005 to 5% by weight of a radical-generating agent, (C) 5 to 60% by weight of a halogen-containing flame-retardant, (D) 100 to 10% by weight of antimony trioxide based upon the said halogen-containing flame retardant, (E)  
125 polyolefin resin.

(2) A flame retardant polyolefin composition obtained by blending various components, where the

percentages are based upon the total weight of the following (A) to (F) constituents, except where a different basis for the percentages is stated: (A) 0.1 to 15% by weight of a crosslinking agent, (B) 0.005 to 5% by weight of a radical generating agent, (C) 5 to 60% by weight of a halogen-containing flame-retardant, (D) 100 to 10% by weight of an antimony trioxide based upon the said halogen-containing flame-retardant, (E) polyolefin resin, and (F) 1 to 10% by weight of a boron compound.

The polyolefin resin is subjected to melting and kneading treatment with at least the crosslinking agent and the radical-generating agent in order to achieve the blended composition.

As polyolefin resins used in the present invention, a homopolymer of an  $\alpha$ -olefin such as propylene, butylene or the like, a random copolymer, a block copolymer consisting selected two or more members of ethylene, propylene and butylene and ethylene vinylacetate copolymer, styrene-butadiene copolymer, ethylene-propylene rubber and a mixture of two or more of these members can be mentioned. Especially a polyolefin resin containing, as a main component, polypropylene resin, is preferable.

As a halogen-containing flame-retardant, an aromatic bromine compound having a melting point of 300°C or higher e.g. decabromodiphenyl oxide, ethylene bis-tetrabromophthalimide or the like is useful. Especially decabromodiphenyl oxide is preferably used.

The amount of addition of said halogen-containing flame-retardant is in the range of 5~60% by weight, preferably 5~50% by weight, most preferably 7~30% by weight.

The amount of addition of antimony trioxide is in the range of 100~10% by weight based upon the above-mentioned halogen-containing flame-retardant agent.

As crosslinking agent, polyfunctional monomers, monofunctional monomers, oxim nitroso compound, maleimide compound, silane coupling agent, etc. are used.

As concrete examples, there are, for example, triallyl cyanurate, triallylisocyanurate, diethylene glycol dimethacrylate, trimethylolpropane triacrylate, trimethylolpropane trimethacrylate, pentaerythritol triacrylate, pentaerythritol tetraacrylate, divinylbenzene, diallylphthalate, divinylpyridine, vinyltoluene, ethylvinylbenzene, styrene monomer quinonedioxime, benzoquinonedioxime, p-nitrosophenol, N,N'-m-phenylenebis-maleimide, vinyltriethoxysilane,  $\gamma$ -methacryloxypropyl-trimethoxysilane,  $\gamma$ -aminopropyltriethoxysilane, etc.

The amount of addition of said crosslinking agent is in the range of 0.1~15% by weight, preferably 0.5~10% by weight, most preferably 1~6% by weight.

As radical generating agents, materials which generate a radical by thermal decomposition is useful. For example, they are dicumyl peroxide; 2,5-dimethyl-2,5-di(t-butyl peroxy)hexane, 2,5-dimethyl-2,5-di(t-butyl peroxy)hexyne-3; 1,3-bis(t-butylperoxyisopropyl)benzene; 1,1,4,4,7,7-hexamethylcyclo 4,7-diperoxononane; cumenehydroperoxide; cumylperoxotrimethyl silane, etc.

agent varies according to the kind of it, and it is in the range of 0.005~5% by weight, particularly 0.01~1% by weight.

As boron compounds, borax, borofluoride salt, for example, sodium borofluoride, potassium borofluoride, ammonium borofluoride are useful.

The amount of addition is in the range of 1~10% by weight, preferably 1~8% by weight, most preferably 2~6% by weight.

In the present invention, various kinds of additives, for example, antioxidant, lubricant, pigment, inorganic filler (for example, calcium carbonate, talc, clay, mica, magnesium hydroxide, glass fibers, etc.) can be used simultaneously.

In the production of the present composition, there is no particular limitation in the order of addition of each component of the above-mentioned (A), (B), (C), (D) and (E). Any of the following methods i.e. a method of simultaneous mixing of (A), (B), (C), (D) and (E)

followed by melting and kneading; a method in which (A) and (B) are added during the processing of melting and kneading of (C), (D) and (E) and a method in which after melting and kneading of (A), (B) and (E) in advance, (C) and (D) are mixed and melting and kneading are carried out subsequently. Further, there is also no particular limitation in the order of addition of each components of above-mentioned (A), (B), (C), (D), (E) and (F). Any one of the following methods i.e. a method in which (A), (B), (C), (D), (E) and (F) are simultaneously mixed and subjected to melting and kneading; a method in which after melting and kneading of (A), (B) and (F) in advance, (C), (D) and (E) are mixed and subjected to melting and kneading; or a method in which (A) and (B) are added during the processing of mixing, melting and kneading of (C), (D), (E) and (F) and further subjected to melting and kneading, is applicable.

As an apparatus for mixing the above-mentioned each components, a common mixing apparatus such as a mixer having an attached high speed stirrer e.g. Henschel mixer (name of article of trade) ribbon blender, tumbler may be useful. For melting and kneading, a common single or twin screw extruder can be used. Melting and kneading temperature is in the range of 170°C~300°C, preferably 200°C~260°C. Retention time in the extruder of product mixed by melting will be sufficient if a retention time in a common extruder is used.

From the pellets of polyolefin composition, thus obtained, test specimen of predetermined dimension were molded and flame-retardancy and mechanical strength were measured. With regard to flame retardancy, extremely better flame-proofness and dripping property were indicated, compared with comparative test specimens. Further, in mechanical strength, flexural modulus, flexural strength, tensile strength, Izod impact strength, the test specimen show higher numerical values in all these tests compared with comparative test specimen and it has been revealed that increase of mechanical strength of formed articles as well as improvement of a large extent of flame-retardancy and dripping property can be attained.

The present invention will be more concretely illustrated by referring to specific examples and

examples and Comparative examples were carried out according to the following method. Further the measurements of mechanical strength were carried out according to the method of JISK 6758-1981.

#### 5 Burning test

- Test specimens having a length of 127 mm, a width of 12.7 mm and a thickness of 0.8 mm were vertically suspended by fixing at the top end in a room in which there is no movement of air. A flame of Bunsen burner having been controlled to produce a 19 mm blue flame was applied to a test specimen from its lower end for 10 seconds. After 10 seconds, the burner was removed and a time at which the test specimen continues to burn with flaming after removal of the burner, was measured and this is recorded as the first flaming combustion time. Immediately after extinguishment of test specimen, a blue flame of burner was applied again to the test specimen at its lower end according to the same method for 10 seconds and a time elapsed until extinguishment was attained again was measured and this is recorded as the second flaming combustion time. Subsequently a time during which the test specimen is burning with glowing combustion is also measured. This time are summed up with the above-mentioned second flaming combustion time and recorded as a glow time. Further, cotton is placed at the position 305 mm below the test specimens and observed whether it catches fire by flaming drip

during the testing time and the result is recorded.

- 30 Foregoing tests were carried out by using 5 test specimens and fire-retardancy was evaluated. *Specific examples 1~2 and Comparative examples 1~3*

- After definite amounts of a halogen-containing flame-retardant, antimony trioxide, a crosslinking agent, and a radical generating agent having the details described in Table 1 were mixed with, as polyolefin resin, ethylene-propylene block copolymer having a melt flow rate (M.F.R.) of 2.5 g/10 min. (the extruded amount of melted resin for 10 minutes at the time when 2.16 Kg of load is applied at 230°C) and ethylene content of 12% by weight or a propylene homopolymer having a M.F.R. of 2.0 g/10 min. the mixture was melted and kneaded (mean retention time of 25 sec.) at 230°C by using a twin screw extruder having a diameter of 45 mm (Brand PCM-45 of Ikegai Tekkosho K.K. to do pelletizing. As Comparative examples 1~3, each of the components described in Table 1 was mixed, melted, and kneaded according to the method the same as that of Examples 1~2 to do pelletizing. Resulting pellets were charged an injection molding machine to mold test specimen of definite dimension, which were subjected to the measurement of flammability and mechanical strength. The result are shown in Table i.

Table 1.

	Unit	Example 1	Comparative example 1	Comparative example 2	Example 2	Comparative example 3
Polyolefin resin E1	% by weight	67	70	40	-	-
" E2	"	-	-	-	37	40
Halogen-containing flame-retardant C1	"	20	20	40	40	40
Antimony trioxide D	"	10	10	20	20	20
Crosslinking agent A1	"	3	-	-	3	-
Radical generator B1	"	0.01	-	-	0.01	-
First flaming combustion time	sec.	2	*1)	0.5	0.5	0.5
Whether or not drip formed at the first combustion time	-	no	yes	no	no	no
Second flaming combustion time	sec.	1	*1)	*2) not clear	0.5	*2) not clear
Whether or not drip formed at the second combustion time	-	no	yes	yes	no	yes
Whether or not cotton ignited	-	no	yes	no	no	no
Glow time	sec.	45	not measurable *3)	not measurable *3)	55	not measurable *3)

Table 1 (continued)

	Unit	Example 1	Compar. ex. 1	Compar. ex. 2	Example 2	Compar. ex. 3
Mechanical strength	Flexural modulus	Kg f/cm <sup>2</sup>	15,000	14,400	-	-
	Flexural strength	Kg f/cm <sup>2</sup>	350	315	-	-
	Tensile strength	Kg f/cm <sup>2</sup>	275	225	-	-
	Izod impact strength (with notch)	Kg f.cm/cm	6.3	6.0	-	-

Note: A1: trimethylolpropanetriacrylate,

B1: 1,3-bis(t-butylperoxyisopropyl)benzene,

E1: ethylene-propylene block copolymer having 12% by weight of ethylene,

E2: propylene homopolymer.

\*1) "a" shows that test specimen continued to burn with flaming.

\*2) "not clear" shows that combustion time could not be measured due to melt-falling at the time when a burner applied to the test specimen.

\*3) "not measurable" shows measurement of glow time could not be done due to melt-falling of the test specimen.

As evident from Example 1, Comparative examples 1~2 those which did not use a crosslinking agent and a radical generating agent were not extinguished as in Comparative example and fall of drip with flaming combustion was observed. Further, those in which the amount of a flame-retardant and antimony trioxide were increased, were satisfactory in combustion time but melting and falling of test specimens were observed by the second combustion. In contrast, Example 1 showed excellent extinguishment and dripping property in spite of its same amounts of addition of the flame-retardant and antimony trioxide as in Comparative example 1. Particularly, at the second combustion time, notable difference in dripping property was observed. Further, as for mechanical strengths, higher numerical values were indicated in flexural modulus, flexural strength, tensile strength, Izod impact strength, etc. compared with those of Comparative example 1.

In specific example 2, a propylene homopolymer having a melt-flow rate 2.0 g/10 min. was used as a polyolefin resin and subjected to similar tests but it was revealed that a great extent of flammability and dripping property were improved at the time of the second combustion as compared with those of Comparative example 3.

#### Examples 3~4 and Comparative examples 4~7

To polypropylene homopolymer having a M.f.r. of 2.0 g/10 min., as a polyolefin resin, a halogen-containing flame-retardant, antimony trioxide, a crosslinking agent a radical generating agent, and a boron compound, the details of which are described

in Table 2, each in definite amounts were admixed in a Henschel mixer (FM-75C manufactured by Mitsui Miike Seisakusho), and thereafter by using a twin screw extruder having a diameter of 45 mm (PCM-45, of Ikegai Tekko K.K.), melting and kneading were carried out at 230°C (mean retention time in the extruder 25 sec.) to effect pelletizing. As Comparative examples 4~7, each of the components described in Table 2 were mixed, melted and kneaded according to the method the same with those of Examples 3~4, to effect pelletizing. Resulting pellets were charged to an injection molding machine to mold into test specimen of definite dimension at a temperature of 250°C, and the molded test specimens were subjected to the measurement of flammability and mechanical strength. The results of these tests are shown in Table 2.

#### Examples 5~9 and Comparative examples 8~9

By using, as polyolefin resin, an ethylene-propylene block copolymer having a M.F.R. of 2.5 g/10 min. and further using, in Examples 6~7, as inorganic filler, talc and wollastonite, definite amounts of each of the components the detail of which are described in Table 3, were mixed, melted and kneaded according to a method similar to that of specific examples 3~4 to effect pelletizing.

By using the resulting pellets, test specimen of definite dimension were molded according to a method described in specific examples 3~4 and measurements of flammability and mechanical strength were conducted. The results of these tests are indicated in Table 3.

Table 2

	Unit	Example 3	Example 4	Compar. ex. 4	Compar. ex. 5	Compar. ex. 6	Compar. ex. 7
Polyolefin resin F1	% by weight	62	62	65	37	40	30
Halogen-containing flame-retardant C1	"	20	-	20	40	40	40
" C2	"	-	20	-	-	-	-
Antimony trioxide D	"	10	10	10	20	20	20
Crosslinking agent A1	"	3	3	0	3	0	0
Radical generating agent B1	"	0.01	0.01	0	0.01	0	0
Boron compound E1	"	5	5	5	0	0	10
First combustion time	sec.	7	11	6	0.2	0.2	0.2
Whether or not drip is present at the first combustion time	-	no	no	yes	no	no	no
Second combustion time	sec.	5	5	*1)	1	5	8
Whether or not drip is present at the second combustion time	-	no	no	yes	no	yes	yes
Whether or not ignited the cotton due to drip	-	no	no	yes	no	no	no
Glow time	sec.	25	55	unmeasurable <sup>*2)</sup>	70	unmeasurable <sup>*2)</sup>	unmeasurable <sup>*2)</sup>

Table 2 (continued)

		Unit	Example 3	Example 4	Compar. ex. 4	Compar. ex. 5	Compar. ex. 6	Compar. ex. 7
Mechanical strength	Flexural modulus	Kg f/cm <sup>2</sup>	22,500	-	19,400	-	-	-
	Flexural strength	Kg f/cm <sup>2</sup>	490	-	455	-	-	-
	Tensile strength	Kg f/cm <sup>2</sup>	320	-	300	-	-	-
	Izod impact strength	Kgf·cm/cm	3.6	-	3.6	-	-	-

Note: A1: trimethylolpropanetriacrylate,

B1: 1,3-bis(t-butylperoxyisopropyl)benzene,

C1: decabromodiphenyl oxide,

C2: ethylenebistetra bromophthalimide,

E1: sodium borofluoride,

F1: propylene homopolymer (M.F.P. 2.0 g/10 min.),

\*1) "-" shows that a test specimen continued to burn.

\*2) "unmeasurable" means that the measurement of glow time could not be measured due to the melt-falling of test specimen.

Table 3

		Unit	Specific ex. 5	Comparative example		Specific example			
				8	9	6	7	8	9
Polyolefin resin	F1	% by weight	62	62	30	50	50	62	62
Halogen-containing flame retardant	C1	"	20	20	40	20	20	20	20
Antimony trioxide	D	"	10	10	20	10	10	10	10
Crosslinking agent	A1	"	3	3	0	3	3	-	3
"	A2	"	-	-	-	-	-	3	-
Radical generating agent	B1	"	0.01	0	0	0.01	0.01	0.01	0.01
Boron compound	E1	"	5	5	10	5	5	5	-
"	E2	"	-	-	-	-	-	-	5
Inorganic filler	G1	"	0	0	0	12	0	0	0
"	G2	"	0	0	0	0	12	0	0
First combustion time		sec.	6	9	0.2	9	3	11	7
Whether or not drip is present at the first combustion time		-	no	yes	no	no	no	no	no
Second combustion time		sec.	4	-	2	1	4	8	5
Whether or not drip is present at the second combustion time		-	no	yes	yes	no	no	no	no
Whether or not ignited cotton is present or not due to drip		-	no	yes	no	no	no	no	no
Glow time		sec.	26	unmeasurable	unmeasurable	40	35	50	30

Table 3 (continued)

		Unit	Specific ex. 5	Comparative example		Specific example			
				8	9	6	7	8	9
Mechanical strength	Flexural modulus of elasticity	Kgf/cm <sup>2</sup>	15,800	15,700	-	-	-	-	-
	Flexural strength	"	360	330	-	-	-	-	-
	Tensile strength	"	265	220	-	-	-	-	-
	Izod impact strength	Kgf·cm/cm	6.1	5.8	-	-	-	-	-

Note: A2: pentaerythritol triacrylate

E2: borax

P2: ethylene-propylene block copolymer containing 12% by weight of ethylene

G1: Talk

G2: Wollastonite

Others are the same with the note of Table 2.

As understandable from the description of Table 2, it can be seen that extinguishing property, glow time and dripping property are all greatly improved. Namely, as indicated in Comparative example 6, simple increase of the amount of a halogen-containing flame-retardant and antimony trioxide provides good extinguishing property but melt-falling of test specimen were observed and dripping property was not improved at all. It can be seen that those in which combination same with that of specific example 3 was made except that a crosslinking agent and a radical generating agent as in Comparative example 4 were not added, did not show extinguishment and melt fallen materials were observed, and it is observed that neither extinguishing property nor dripping property was improved. Those in which addition of a halogen-containing flame retardant and antimony trioxide was merely increased, relative to Comparative example 4 as in Comparative example 7 improves extinguishing property but melt falling of test specimen was observed and dripping property was not improved. Further, in a system in which a boron compound was removed from specific example 3, as in Comparative example 5, extinguishment property and dripping property showed satisfactory result but a glow time was considerably longer. The first goal of this glow time is 30 seconds or less and the second goal is 60 seconds or less but considering from these results, it cannot be said that this system is satisfactory. Whereas it has been revealed that extinguishment property, glow time and dripping property were all improved. Further, specific example 4 is directed to a case where ethylene bis(tetra - bromophthalimide) was used as a halogen-containing flame-retardant but extinguishment property and dripping property are improved.

Referring now Table 3, specific example 5 is directed to a case where an ethylene propylene block copolymer having an ethylene content of 12% by weight (M.F.R. 2.5 g/10 min.) was used as a polyolefin resin and showed good extinguishment, glow time and dripping property, similarly as in specific example 3. Comparative example 8 is directed to a case where only a radical generating agent is removed from specific example 5 but it is seen that both extinguishment and dripping property were worse and the effectiveness of a crosslinking agent is not exhibited due to the non-existence of a radical generating agent. It is observed that simple increase of the amounts of a halogen-containing flame-retardant, and antimony trioxide, makes extinguishment better similarly as in Comparative example 7; melt-falling of test specimens were observed.

Further, specific examples 6~7 correspond to the cases where an inorganic filler are added to specific example 5. Self-extinguishment and dripping property were good but a glow time is inferior to specific example 5 to some extent. Specific example 8 is directed to a case where pentaerythritol triacrylate is

directed to a case where borax is used as a boron compound and it has been revealed that superior extinguishment, dripping property and glow time were exhibited as in specific example 5.

#### CLAIMS

1. A flame-retardant polyolefin composition comprising the following components (A), (B), (C), (D), (E) and optionally (F), where the percentages are based on the total weight of the components (A) to (E) or (A) to (F), except where a different basis is specified: (A) 0.1 to 15% by weight of crosslinking agent; (B) 0.005 to 5% by weight of a radical-generating agent; (C) 5 to 60% by weight of a halogen-containing flame-retardant; (D) 100 to 10% by weight of antimony trioxide relative to the halogen-containing flame-retardant; (E) polyolefin resin; and (F) optionally 1 to 10% by weight of a boron compound.

2. A flame-retardant polyolefin composition according to Claim 1, wherein the polyolefin resin is at least one resin selected from propylene homopolymer; a random copolymer of two or three of ethylene, propylene and butylene; a block copolymer of two or three of ethylene, propylene and butylene; ethylene-vinylacetate copolymer; or ethylene-propylene rubber.

3. A flame-retardant polyolefin composition according to Claim 1 or 2 wherein the crosslinking agent is at least one agent selected from triallyl cyanurate, triallyl isocyanurate, diethyleneglycol dimethacrylate, trimethylol propanetriacrylate, trimethylol propane trimethacrylate, pentaerythritol triacrylate, pentaerythritol tetraacrylate, divinyl benzene, diallyl phthalate, divinyl pyridine, vinyl toluene, ethyl vinyl benzene, styrene monomer, quinone dioxime, benzoquinone dioxime, p-nitrosophenol N,N'-m-phenylene bis maleimide, vinyltriethoxysilane,  $\gamma$ -methacryloxypropyltrimethoxysilane or  $\gamma$ -aminopropyltriethoxysilane.

4. A flame-retardant polyolefin composition according to Claim 1, 2 or 3 wherein the halogen-containing flame-retardant is at least one flame-retardant selected from decabromodiphenyloxide and ethylene - bis - tetrabromophthalimide.

5. A flame-retardant polyolefin composition according to any preceding Claim wherein the radical generating agent is at least one agent selected from dicumyl peroxide, 2,5 - dimethyl - 2,5 - di - (t-butylperoxy)hexane, 2,5 - dimethyl - 2,5 - di - (t-butylperoxy)hexane - 3; 1,3 - bis(t-butylperoxyisopropyl)benzene, 1,1,4,4,7,7 - hexamethylcyclo - 4,7 - diperoxynonane, cumenehydroperoxide and cumylperoxytrimethylsilane.

6. A flame-retardant polyolefin composition according to any preceding claim wherein the boron compound is present and is at least one compound selected from borax, potassium borofluoride, sodium borofluoride and ammonium borofluoride.

7. A flame-retardant polyolefin composition

according to any preceding claim, when prepared by mixing the components (A) to (E) and also (F) when required, and melting and kneading the mixture.

8. A flame-retardant polyolefin composition  
5 according to any of claims 1 to 7, when prepared by mixing the components (A), (B) and (E), melting and kneading the mixture, and blending in the components (C) and (D) and also (F) when required.

9. A flame-retardant polyolefin composition  
10 according to any preceding claim, wherein the percentage amount for at least one of the following components is in ranges:

(A) 0.5 to 10%; (B) 0.01 to 1%; (C) 5 to 50%; or (F) 1 to 8%; where the bases for the percentages are as in

- 15 claim 1.

10. A flame-retardant polyolefin composition according to any preceding claim and containing one or more further components.

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